	Baseline design	New design
Hemolysis index	0.02	0.002
Thrombus formation	yes	no
Test run time	2 days	30+days

Fig. 3. Performance of the new VAD design.

efficiency of flow through the device. Second, CFD results suggested that the original design of the device caused clotting in the front bearing area where the blood passes over the flow straightener and meets the impeller blades. Expanding the hub area's width increased the circulation of blood, eliminating stagnant sections where clotting was known to occur. Additionally, researchers tapered the hub surface, accelerating blood flow, and thus creating good wall washing. And third, the exiting flow angle of the blood was examined and the diffuser angle was repositioned. Changing the diffuser blade angle aligns it with the blood flowing through the device, creating a smoother transition of blood over pump surfaces, and reducing the shear stress that causes cell damage.

Clinical tests conducted by MicroMed Technology and Baylor College of Medicine have confirmed the improvement in performance—hemolysis was decreased tenfold (figure 3). In collaboration with designers at MicroMed Technology, modifications made through the use of CFD analysis have resulted in a device that can perform for more than 100 days. The longest successful trial period to date in a human was 110 days, after which a donor heart was transplanted. The team's ultimate goal is to make the VAD a permanent alternative to heart transplant surgery. Successful European trials of the device in humans suggest its ability to provide long-term ventricular assistance.

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Application of Rotary-Wing Technologies to Planetary Science Missions

Larry A. Young

The next few years promise a unique convergence of NASA aeronautics and space programs. NASA planetary science missions are becoming increasingly more sophisticated and this will ultimately culminate, in part, in the development of planetary aerial vehicles (PAVs). Early work in this area has principally focused on conceptual design of fixed-wing aircraft configurations for Martian exploration. However, autonomous vertical-lift vehicles—and rotary-wing technologies in general—hold considerable potential for supporting planetary science and exploration missions.

For planetary science missions to Venus, Mars, and Titan, vertical-lift vehicles (using rotors as the means of propulsion) could potentially be developed and flown to support robotic science missions to these two planets and Saturn's moon (figure 1). For missions to Jupiter, Saturn, Uranus, and Neptune, vertical-lift capability is not required for PAVs supporting scientific investigations of the gas-giant planets. However, rotary-wing technologies, such as aeromechanics for PAV propeller design, could still be applicable for vehicles developed for these planets.

Autonomous vertical-lift PAVs would have the following advantages and capabilities when used for planetary exploration:

1. Their hover and low-speed flight capability would enable detailed and panoramic surveys of remote sites.
2. They would enable remote-site sample return to lander platforms or precision placement of scientific probes or both.
3. Soft landing capability would enable vehicle reuse (that is, lander refueling and multiple sorties) or remote-site monitoring and exploration.
4. Hover and soft landing provide good fail-safe "hold" modes for autonomous operation of PAVs.

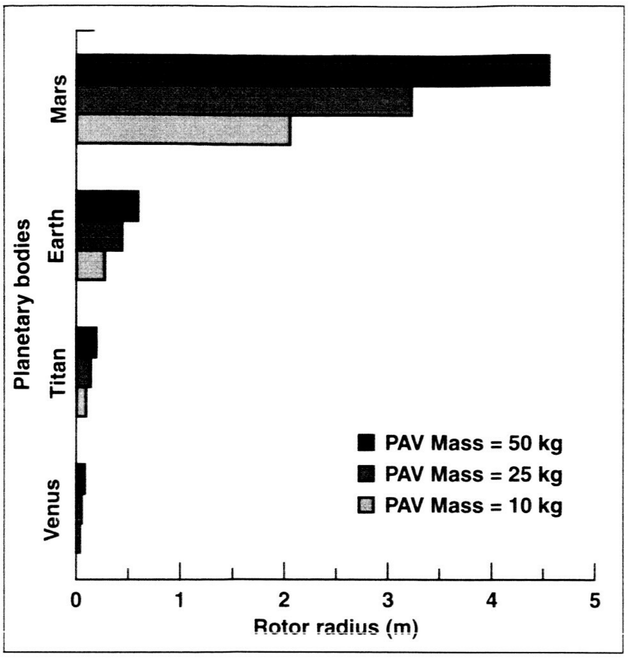

Fig. 1. Comparison of rotors sized for hover (for equivalent values of tip Mach number, solidity, and mean lift coefficient).

5. They would provide greater range, speed, and access to hazardous terrain than a surface rover.

6. They would provide greater resolution of surface details or observation of atmospheric phenomena than an orbiter.

The objective of the work being performed is to assess the feasibility of developing vertical-lift planetary aerial vehicles. Work to date has focussed on a conceptual design study of a Martian Autonomous Rotorcraft for Science (MARS). Given the thin, carbon-dioxide-based Martian atmosphere, developing a rotorcraft that can fly in that planetary environment will be very challenging. A university grant has been initiated to develop a conceptual design of a mission and flight-control computer architecture.

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Ballistic Range Tests Verify Stability of a Loaf-Shaped Entry Vehicle

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An entry vehicle whose shape resembles that of a loaf of bread has been proposed for missions to be flown as secondary payloads on the Ariane V launch vehicle. This shape conforms well within the volume available inside the Ariane structure for auxiliary payloads, and provides a much more efficient and larger internal packaging capability for the given launch-vehicle constraints than the conventional sphere-cone geometry (such as that of the Mars-Pathfinder entry vehicle). Because aerodynamic stability for this new class of vehicles must be evaluated, initial ballistic range testing was conducted to assess the supersonic behavior of loaf-shape vehicles. Figure 1 shows a shadowgraph image of the ballistic range model flying at supersonic speeds.

The loaf-shaped model for the ballistic range tests is sized to be launched from a 1.75-inch-bore gun. The model has geometry and mass properties that are similar to those being considered for the mission. Model dimensions are 1.15 x 0.78 x 0.66 inches and

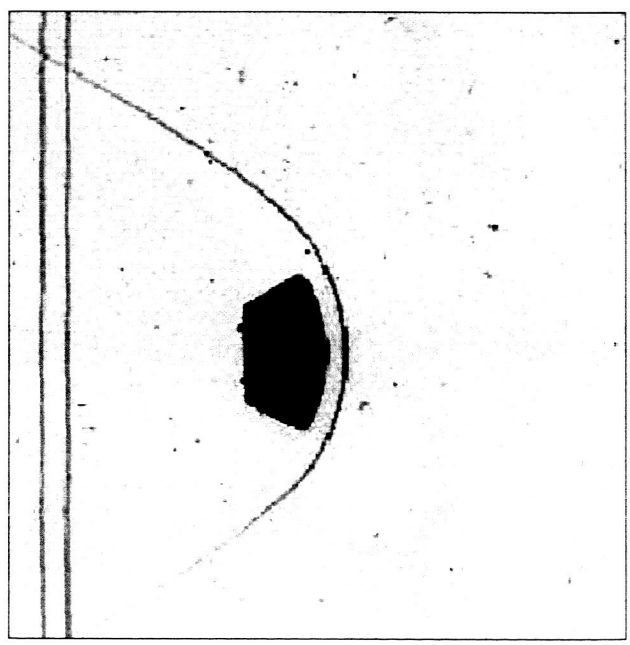

Fig. 1. Sample shadowgraph from aeroballistic testing of loaf-shaped entry vehicle.